Jacques Bertin

Graphics and Graphic Information-Processing

Translated by
William J. Berg and Paul Scott

Walter de Gruyter
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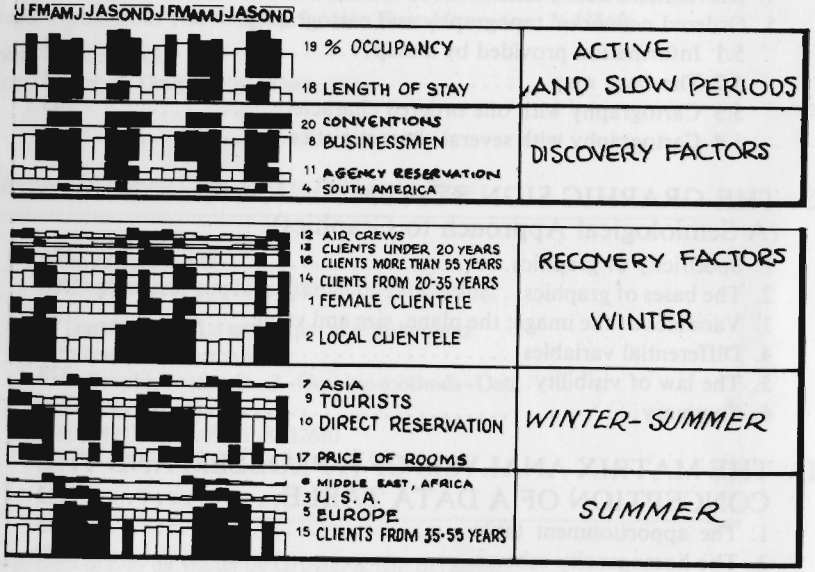
J	F	M	A	M	J	J	A	S	O	N	D		
26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE
69	70	77	71	37	36	39	39	55	60	68	72	2	% —"— LOCAL
7	6	3	6	23	14	19	14	9	6	8	8	3	% —"— U.S.A.
0	0	0	0	8	6	6	4	2	12	0	0	4	% —"— SOUTH AMERICA
20	15	14	15	23	27	22	30	27	19	19	17	5	% —"— EUROPE
1	0	0	8	6	4	6	4	2	1	0	1	6	% —"— M.EAST. AFRICA
3	10	6	0	3	13	8	9	5	2	5	2	7	% —"— ASIA
78	80	85	86	85	87	70	76	87	85	87	80	8	% BUSINESSMEN
22	20	15	14	15	13	30	24	13	15	13	20	9	% TOURISTS
70	70	75	74	69	68	74	75	68	68	64	75	10	% DIRECT RESERVATIONS
20	18	19	17	27	27	19	19	26	27	21	15	11	% AGENCY —"—
10	12	6	9	4	5	7	6	6	5	15	10	12	% AIR CREWS
2	2	4	2	2	1	1	2	2	4	2	5	13	% CLIENTS UNDER 20 YEARS
25	27	37	35	25	25	27	28	24	30	24	30	14	% —"— 20-35 —"—
48	49	42	48	54	55	53	51	55	46	55	43	15	% —"— 35-55 —"—
25	22	17	15	19	19	19	19	19	20	19	22	16	% —"— MORE THAN 55 —"—
163	167	166	174	152	155	145	170	157	174	165	156	17	PRICE OF ROOMS
1.65	1.71	1.65	1.91	1.90	2.	1.54	1.60	1.73	1.82	1.66	1.44	18	LENGTH OF STAY
67	82	76	83	74	77	56	62	90	92	78	55	19	% OCCUPANCY
			X	X	X			X	X	X	X	20	CONVENTIONS

1

2



Once upon a time there was a manager of a large hotel, anxious to improve his establishment's performance. He had his staff compile various statistics. The table of figures **(1)** remained on his desk for a number of days.

Then one day his assistant presented him with a graphic **(2)** constructed from the data table. After a few moments' attention, the manager summoned his staff, and with them
— defined a new price structure,
— modified the services offered to the guests,
— reorganized supplies,
— and modified his promotion campaign.
Then he rounded off the day with a visit to the mayor of the city, whose duties included the scheduling of conventions.

The results of his efforts assured him of rapid promotion.

This example demonstrates that it is not sufficient to have data, to have statistics, in order to arrive at a decision. Items of data do not supply the information necessary for decision-making. What must be seen are the relationships which emerge from consideration of the entire set of data. *In decision-making the useful information is drawn from the overall relationships of the entire set.*

This example also shows that graphics can uncover these overall relationships. That is its purpose. In contrast with pictography, graphics is not an art. It is a strict and simple system of signs, which anyone can learn to use and which leads to better understanding. Thus, it leads to better decision-making.

A. POSTMORTEM OF AN EXAMPLE

1. THE STAGES OF DECISION-MAKING

Let us take a closer look at the hotel manager's problem.
It enables us to schematize the stages of analysis and decision-making.
It illustrates the role of graphics in these stages.
It gives a visible form to the problems encountered in information-processing.
It indicates the means of defining a useful graphic construction.

1.1 1st Stage: Defining the Problem

The manager hopes to improve the operation of his hotel. What decision must be made? To decide is to choose, and to choose he must first be "informed." He clarifies his problem by asking certain questions: Is full occupancy guaranteed? Are there slow periods? When? Where does the clientele come from in summer? In winter? Who are they? The problem is defined by progressively simpler questions which permit the composition of a list of potentially useful items of information. Note that this list of basic questions and useful information is purely a problem of imagination which no machine could solve. This first and fundamental stage in decision-making cannot be automated.

1.2 2nd Stage: Defining the Data Table

This stage is limited by the means and time available. Will the entire list of imagined questions be retained? Will the information be gathered by month, by week, or by day, each multiplying the work involved? A list of twenty monthly indicators seems sufficient here.
Once the useful statistics are defined in nature and number, the assistant gathers the necessary figures from the data in the hotel records.
Will he construct several tables, one for where the guests come from? another for their age? a third for data related to operating the hotel, etc. . . . ? No. He decides on a single table. Let us imagine his reasoning:

J	F	M	A	M	J	J	A	S	O	N	D		
26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE
69	70	78	71	57	36	39	39	55	60	68	72	2	% —"— LOCAL
7	6	3	6	23	14	19	14	9	6	8	8	3	% —"— U.S.A
0	0	0	0	8	6	6	4	2	13	0	0	4	% —"— SOUTH AMERICA
20	15	14	15	23	27	22	30	27	19	19	17	5	% —"— EUROPE
1	0	0	8	6	4	6	4	2	1	0	1	6	% —"— M.EAST, AFRICA
3	10	6	0	3	13	8	9	5	2	5	2	7	% —"— ASIA
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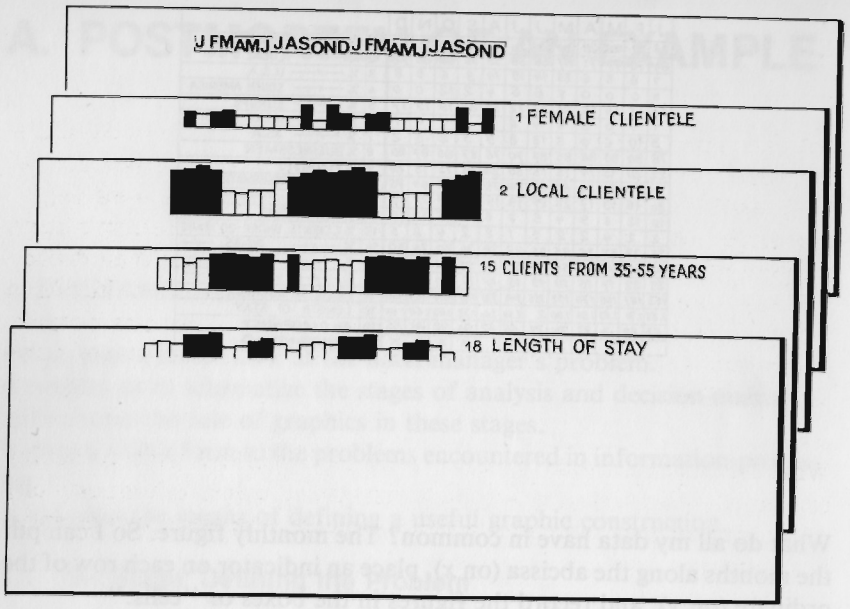
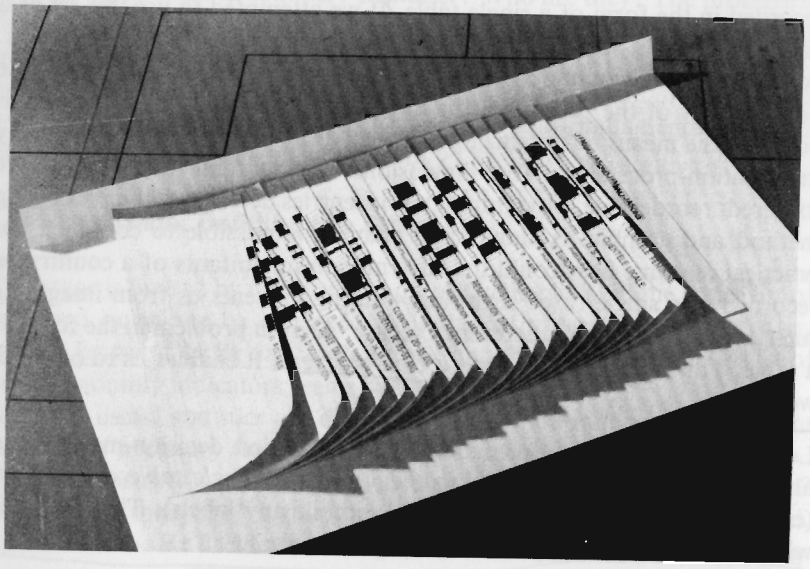
			X	X	X			X	X	X	X	20	CONVENTIONS

What do all my data have in common? The monthly figure. So I can put the months along the abcissa (on *x*), place an indicator on each row of the ordinate (on *y*), and record the figures in the boxes or "cells."

Let us note the unity of the data table; indeed, the use of a single table indicates that the problem is well defined. Suppose that the assistant had also included the number of rooms, beds, people, repairs per floor. If this were added to the preceding information, the entire set of data could not be recorded in the form of a single table. If we attempted to use this set as a basis for analysis, we would be mixing two completely unrelated problems. Something still encountered all too frequently. This single table proves the homogeneity of the problem. It is the basis for all analysis, conscious or not. It is the means of organizing research. It is the starting point for any information-processing. The dimensions of the table and the nature (ordered, reorderable, topographic) of its entries determine the processing method and graphic. A single table may be impossible to construct for practical reasons: how could the fifty million inhabitants of a country be recorded in a single row? However, nothing prevents us from imagining such a construction and therefore "seeing" a given problem in the form of a table. This is the *matrix analysis of a problem*. It enables us to organize work.

Let us note that the information which preceded decision-making can always be *written or imagined in the form of a single table of numbers* (cardinal, ordinal or binary numbers without any labels). This principle will be a unifying concept throughout the book.





1.3 3rd Stage: Adopting a Processing Language

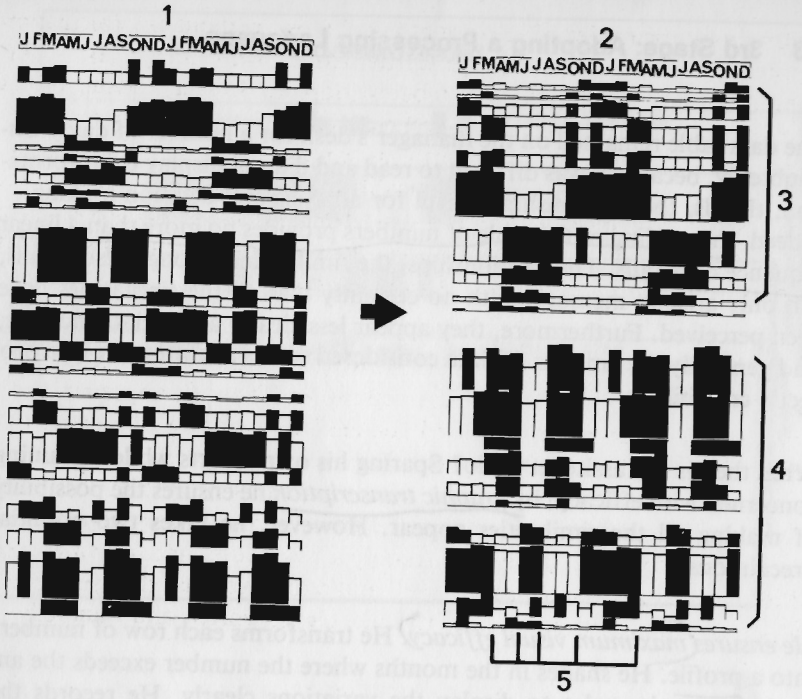
The data table remained on the manager's desk for a number of days. Undoubtedly, because it was difficult to read and did not display the information, that is, the relationships useful for analysis and decision-making. Indeed, the reading of the table of numbers provides no more than a linear sequence of details. The relationships, the similarities among these details, can only arise in memory, with no certainty that all the similarities have been perceived. Furthermore, they appear less clearly as the data increase, and generally the amount of data considered serves as a measure of a project's credibility.

What then is the assistant to do? Sparing his own efforts while remaining concerned with efficacy, by *graphic transcription* he ensures the possibility of making all the similarities appear. However, he takes two essential precautions:

He ensures maximum visual efficacy. He transforms each row of numbers into a profile. He shades in the months where the number exceeds the annual average in order to display the variations clearly. He records the twelve months twice so that a potential cycle does not risk being split up and thus overlooked.

He ensures the mobility of the image. He constructs each profile on a separate card (image-file). Thus he draws each profile only once, but he remains free to class the profiles in different ways and to construct different images from the same drawing.

This is a fundamental point, because it is the internal mobility of the image which characterizes modern graphics. A graphic is no longer "drawn" once and for all; it is "constructed" and reconstructed (manipulated) until all the relationships which lie within it have been perceived. The practical possibilities for permuting the elements on a diagram are numerous. The means employed by the assistant are simple and within anyone's reach. For the permutation of rows and columns, special equipment is available. Remember that we live in an age of computers and electronic display screens, and that all such permutations can now be carried out by pressing a button.



1.4 4th Stage: Processing the Data: Simplifying Without Destroying

When the cards are classed in the same order as the original table, they construct image **(1)**. If it stopped there, the graphic transcription would be absolutely useless. However, since the rows are physically independent, they may be reclassed to make the similarities appear. It is sufficient to study the cards two by two and to group those which resemble one another **(1→2)**.

The assistant then discovers: a) that the indicators construct two systems of variation, one semi-annual **(3)** the other quarterly **(4)**, and b) that the year can be broken down into four highly differentiated periods **(5)**. Image **(2)** is the *simplification* of image **(1)**.

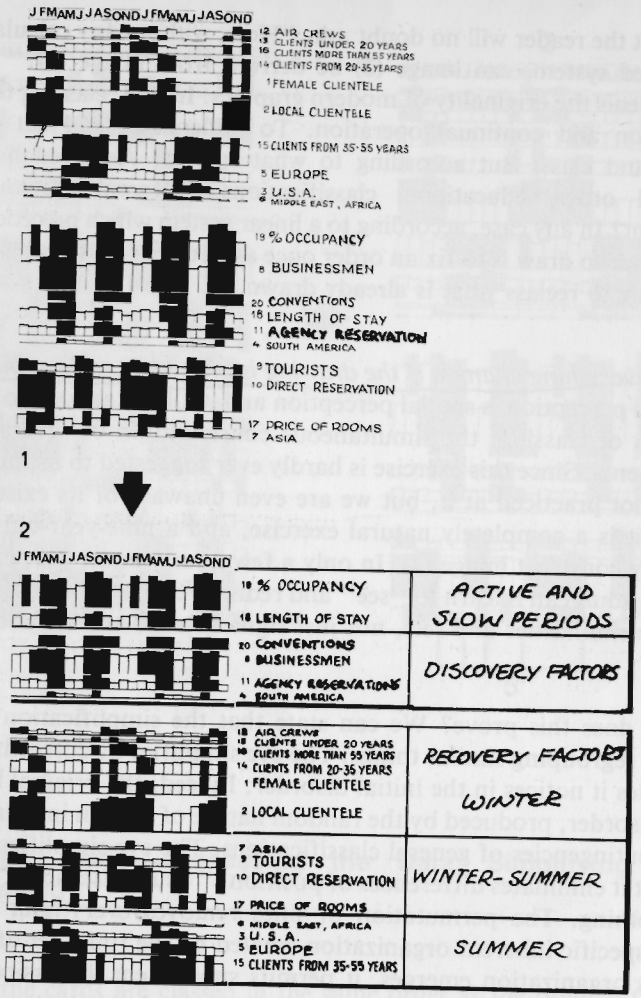
At this point the reader will no doubt ask, "How, without any calculation or predefined system, can image **(2)** be derived from image **(1)**?" This question reveals the originality of modern graphics. In fact, classing things is a common and continual operation. To understand and act is to categorize and class. But according to what system? Acquired habits, alphabetical order, educational classifications, different systems of measurement? In any case, according to a linear system which precedes the drawing, since to draw is to fix an order once and for all. In this sense it is inconceivable to reclass what is already drawn.

However, everything changes if the drawing is physically reclassable. Indeed, visual perception is spatial perception and it allows anyone to use a new system of classing: the simultaneous consideration of several different elements. Since this exercise is hardly ever suggested to us, not only are we not practiced at it, but we are even unaware of its existence. However, it is a completely natural exercise, and a nine-year-old child could easily construct image **(2)**. In only a few hours, under proper conditions, an adult can relearn to "see" and rediscover that the eye is made to perceive similarities and sets, not just signs, words, and numbers.

And what does this prove? We can state that the simplification is no more than regrouping similar things. The eye simplifies by correcting the irregularities it notices in the initial disorder. Indeed, the original inventory is a disorder, produced by the random nature of human imagination and the contingencies of general classifications. The eye simplifies. This means that it eliminates differences of position, "visual distances" which signify nothing. The permutation of lines removes everything which hides the specific inherent organization created by the finite set of data. When this organization emerges, it permits subsequent discussion, not about the organization (which only depends on the data), but:

1. about the nature of the data considered at the outset;
2. about the modifications which would ensure a better understanding of the discovered information.

Let us observe, however, that at the moment of simplification there is no need to refer to the written notations in the legend, that is, to the nature of the concepts, in order to discover the specific order. It depends only on the figures, on the profiles' shape. This operation may therefore be entrusted to a machine; this stage can be automated.



1.5 5th Stage: Interpreting and Deciding . . . . or Communicating

From the moment that the similarities become apparent and create the overall complex of information, the assistant may choose the indicators *which interest him* from the perspective of decisions to make. It is only now that he must be able to read the meaning of each row and each column in order to define his problem. Which is? To ensure maximum occupancy. To eliminate slow periods.

To pose the problem, *he modifies the simplified image* (1→2). He brings those indicators which indicate general activity to the top: percentages of occupancy, length of stay. They indicate the extent to which the hotel is filled and, at the same time, the slow periods, which fluctuate quarterly.

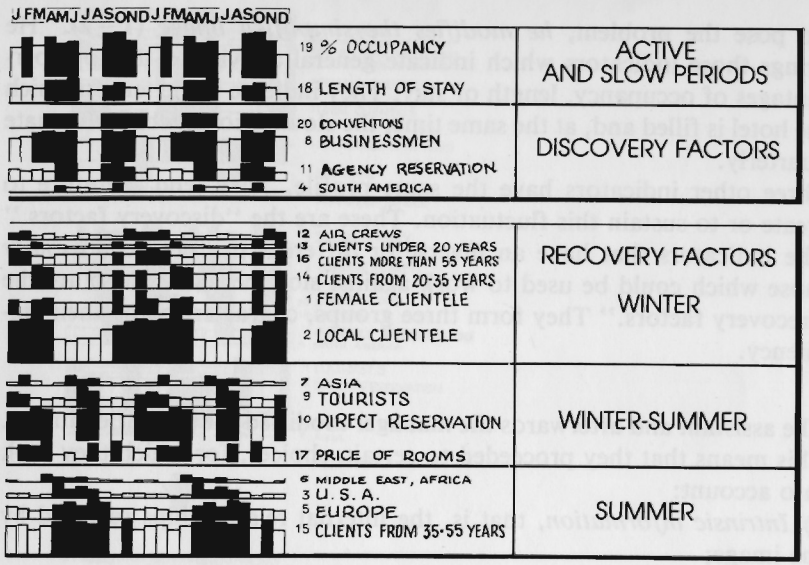
Three other indicators have the same profile. They tend therefore to create or to sustain this fluctuation. These are the "discovery factors." The indicators that have an inverse or different profile are obviously those which could be used to work against slow periods. These are the "recovery factors." They form three groups, characterized by their frequency.

The assistant and afterwards the manager modified the simplified image. This means that they proceeded to certain choices, for which they took into account:

1) *Intrinsic information,* that is, the internal relationships revealed by the image;

2) *Extrinsic information*, that is, the nature of the problem and the interplay of the intrinsic information with everything else. And, by definition, everything else is that which *cannot be processed by machine.* Extrinsic relationships cannot, by definition, be automated. They are, however, of fundamental importance in interpretation and decision-making. Thus, the most important stages—choice of questions and data, interpretation and decision-making—can never be automated. There is no artificial "intelligence."

With this image before him the manager can make decisions. He discovers the characteristics of slow periods: absence of conventions, reduction in the percentage of businessmen, and in the role of travel agencies. But he also discovers that there are marked differences between the summer and winter guests during these slow periods. In winter: more local guests, a higher percentage of women, greater differences in age. In summer: more foreign guests and a more homogeneous age group. These observations add together clearly in the diagram and construct an image of the guests for each period of the year. It is then relatively easy to reorient the promotion campaign and to better structure the services and supplies. Careful analysis reveals that the return sought through variable pricing could be better adjusted. But is this not a discovery factor? Careful analysis also reveals that the December convention does not have the same influence as the others and that moving it or changing it could be beneficial.



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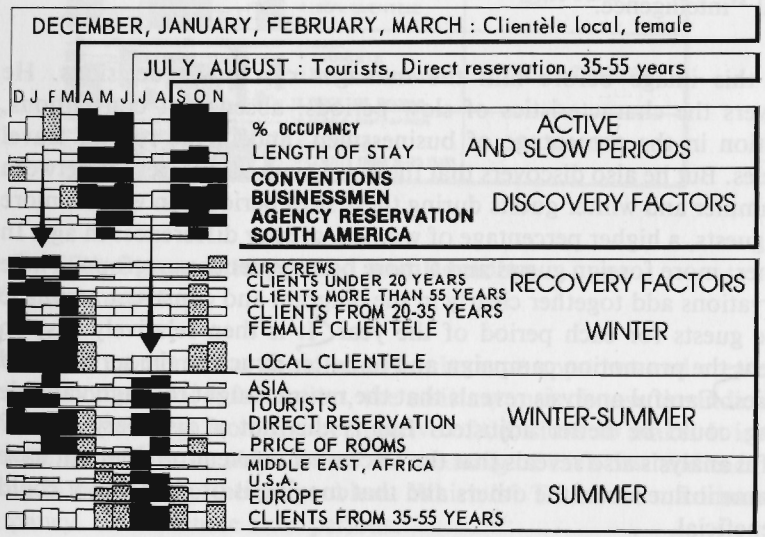

With this image before him the manager can also decide . . . . not to make any decisions and to complete this information by investigating new indicators or by refining the data, down to the weekly level for example. In this case, he would return to the second stage and pick up the cycle from that point, normal procedure in thorough research.

With this image before him, finally, the manager can decide to inform the staff, to convey to them the results of this study. But in that case the image would be too complicated. He simplifies it in order to underline what is important to see, and he works out an explanatory text (2). *A graphic designed for communication highlights the main points* of the results of the investigation.

2. THE AIM OF GRAPHICS: A HIGHER LEVEL OF INFORMATION

2.1 Useful Information

Information is the reply to a question

"In May, which type guest is most common?"
"Guests over 55, when are they most common?"
In any data table there are *two types of question*: questions *introduced by* x, that is by the objects; questions *introduced by* y, that is by the characteristics.
The result is obvious: any graphic construction which does not enable us to find a visual reply to the two types of question provides only one part of the information. To be useful, a construction must above all supply a visual answer to both types of question. *This principle immediately eliminates all graphic constructions which destroy any entry categories used in constructing the data table.*

Useful information involves regrouping

One may wonder why the table of figures remained on the manager's desk for a number of days, while the simplified image (1), although less precise, enabled decisions to be made. It was the discovery of the periods and their characteristics that made it possible to make decisions, as if reading 12 x 20, 240, precise details was less useful than the recognition of four periods and five groups of characteristics (1).